LUBRICATION

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POWER PLANT LUBRICATING EFFICIENCY

Importance of Lubrication

THE lubrication of the power plant is a matter which has not as a rule been given consideration proportionate to its importance. It is estimated that more than fifty per cent. of the total horse-power produced in all power plants is consumed in overcoming friction, and a very considerable proportion of this power is lost through unnecessary friction, faulty lubrication and unsuitable lubricants. In the present days of power plant efficiency, however, efforts are being made on every side to reduce wasted power and frictional losses to a minimum. The power plant engineer is beginning to realize the good results and the economy that can be obtained by giving the subject of lubrication a little thought, and using and properly applying lubricants especially adapted to each condition.

The average power plant engineer has always been content when he could see the cylinders, valves, and bearings showing oil upon the working surfaces, considering that under these circumstances he was getting good lubrication. From all outward appearances this would seem to be the case, but if the proper oil is not being used on the moving parts or is not properly applied, there is, a slow, steady wear which may not be noticeable, but which in the course of several years' time makes it necessary to reconstruct and take up the looseness of the working parts. Although the lubricant may be in evidence at all times, and while the frictional temperature of the bearings may not at any time be at a point to cause alarm, still, if the necessary film of oil between the moving parts is not maintained, undue wear will slowly but surely take place.

SELECTING AN OIL. By far the greatest single factor in putting a power plant upon an efficient lubricating basis is the selection of a proper lubricant. The days of selecting an oil by the old laboratory tests are or should be past. A number of years ago when lubricating oils were practically all made from Pennsylvania crudes, such laboratory tests as gravity, flash, fire, viscosity, and cold test had at least some value as a means of comparing one oil with another for the same purpose. However, as the production of petroleum spread over a number of states and as new crudes having different chemical and physical characteristics were introduced, this comparative value was lost except for oils produced from the same crudes. These laboratory tests today represent, except in one or two instances, obsolete and arbitrary methods of specifying, which in no way indicate the suitability of different oils for different purposes.

The gravity of an oil indicates its weight at 60° F. as compared with that of an equal volume of distilled water at the same temperature. To the well-informed oil man this test has some value in that it indicates to him the source of the crude from which the oil is made. For example, if the oil has a high gravity, it indicates that the crude from which it was made probably came from some of the Northern fields; an intermediate gravity in general would indicate a Mid-continental field, whereas a low gravity would in general indicate a Southwestern crude. If the expert is entirely familiar with the characteristics and lubricating properties of oils made from these different crudes, this test might be of some value, but this knowledge is possessed by very few. A gravity specification today serves only one purpose, namely, to limit the source of supply to certain fields, and needless to say, oil companies who handle crudes from only certain fields naturally use their influence in favor of specifications drawn up to apply to their particular crude. The Texas Company produces its lubricants from Mid-Continental and Southwestern crudes, from asphaltic as well as from paraffine base, therefore producing lubricating oils of all gravities. The fact is, however, that gravity in itself gives absolutely no indication as to the suitability of an oil, and, except as an indication of the crude from which the oil is made, is never given any consideration by the oil expert in selecting an oil for any particular purpose.

The difference in the gravity of different crudes is due to their different chemical composition. This, however, is a very technical question, one which few oil men thoroughly understand, and which is outside of the scope of this article. It is interesting to note in this connection, however, that Archbutt & Deely,* among the best authorities on the subject of lubrication and lubricants, state that the crudes having the chemical composition indicated by the formula C_nH_{2n-4}, which are low gravity crudes, give the lowest co-efficient of friction as well as the greatest durability. According to these authors and according to the eminent investigators, Drs. Mabery and Matthews, this oil proved equal to sperm in reducing friction and superior to castor oil and to blended cylinder oils in durability. This is not due to their low gravity, nor do all low gravity crudes have these characteristics, but the crude having this chemical composition does have a low gravity. It is this low gravity Southwestern crude from which the Texas Company manufactures its highest grade engine and machine oils. In thousands of tests carried on with our oils manufactured from these crudes, the statement of Archbutt and Deely has been sub-

*Archbutt & Deely, *Lubrication and Lubricants*, London, 1912, p. 108

stantiated. With oils made from this crude we have been able to reduce wasted power to a minimum, as well as to show the highest degree of durability.

The flash point of an oil is the temperature at which the oil upon being slowly heated gives off sufficient vapor to form over its surface a mixture with the air which will ignite when a small flame is introduced. This temperature will vary considerably with different instruments and with the different methods of making the test. An oil designated as having a flash of 320 might readily be found upon testing under different conditions to have a flash of 350, due to these variable elements. So far as the lubricating value of an oil is concerned, flash point is of no importance, providing it is sufficiently above the working temperature to prevent too great evaporation of the oil. As the ordinary working temperature of a bearing is from 100° to 175° F., a flash point above 300° F. or thereabout would be high enough to meet all ordinary conditions. The fire point, usually 50 to 75 degrees above the flash point, is the temperature at which the oil gives off sufficient vapor to burn continuously. Obviously this also has no bearing on the lubricating qualities of an oil.

The cold test indicates the lowest temperature at which the oil will flow. Just what cold test an oil should have is determined by the temperature conditions to which the oil is subjected. There are certain conditions under which an oil of a zero cold test is necessary and desirable; there are other conditions under which a cold test of 25° F. or even higher would be perfectly satisfactory. In the ammonia cylinders of ice machines, for example, a zero cold test oil is absolutely necessary. In ordinary bearings which are not exposed to cold weather the cold test is a matter of no importance.

Of all of the laboratory tests before mentioned, viscosity is the most important, as this denotes the body or relative fluidity of the oil. Mineral oils can be manufactured of almost any desired viscosity, and the conditions under which an oil is to be used determines how viscous it should be. In general, light swiftly-moving machinery requires an oil of low viscosity, heavy slow-moving machinery requires an oil of high viscosity; but the viscosity required must be determined in each individual case by the conditions under which the oil is to be used. The body of an oil should be such as to form over the bearings a film of oil just sufficient to keep the surfaces apart under conditions of maximum speed and pressure. An oil too heavy in viscosity produces unnecessary heat due to the internal friction of the oil. An oil too light in viscosity allows actual bearing contact, with a corresponding bearing wear and an increase in frictional heat.

Viscosity is the only one of the tests mentioned above, except in some instances cold test, which has any bearing upon the suitability of a lubricating oil, but an oil might be correct as to viscosity and still prove to be a poor and inefficient lubricant. For example, an oil which has a tendency to decompose and form deposits which will gum up the machine and thereby increase the friction, is obviously to be guarded against, as also the oil which contains ingredients that will corrode or pit the bearing metal. None of the above tests, however, will give the slightest information as to this tendency of the oil. Every precaution should be taken by the oil consumer to guard against such an oil, in other words, he should purchase an oil which is carefully manufactured from a superior crude.

The best practical guide as to the suitability of an oil for any particular purpose is the amount of frictional heat produced with that oil in use

under actual working conditions. Frictional heat denotes wasted power, and is determined by the difference between the bearing temperature and the room temperature. As has been stated, the oils made from the Southwestern low gravity crudes used by The Texas Company for their highest grade engine and machine oils have greater internal lubricating powers than any other oils, and therefore a minimum loss of power is caused by their internal friction. In hundreds of tests under actual working conditions the engineers of The Texas Company have been able to reduce frictional heat from 20% to 50%. In a typical case, for example, bearings running at an average temperature of 101° F., with a room temperature of 71.8° F., that is to say, a frictional heat of 29.2° F., were reduced by Texaco Cetus Oil to an average of 91.6° F., with a room temperature of 71.7° F., that is, 19.9° of frictional heat. This means an actual reduction in frictional heat of 9.3° F., or 31.8%.

The best way to determine the relative values of two or more lubricating oils and the method that is now being generally adopted by large consumers, is to have an engineer make an actual test under working conditions to determine which of the oils under consideration reduces the frictional heat to the lowest point. The question of comparative cost also naturally enters into the selection, and this is determined by computing the cost of lubrication for a certain period, the two factors being, first, the amount of each lubricant necessary to secure perfect lubrication, and second, the cost per gallon of the lubricant. Here again the Southwestern low gravity crudes have the advantage, as better lubrication is secured with the use of less of these oils than is the case with the use of oils made from the high gravity crudes. The cost per gallon may be somewhat higher, but the reduction in consumption more than offsets the difference in original price, the net result being more economical lubrication for any given period. In considering the cost, however, the ultimate cost should always be considered, and in computing the ultimate cost, the loss of power, and the wear on equipment due to unnecessary friction should be given first consideration.

Texaco Lubricants.—The Texas Company produces, manufactures, and markets lubricants of every variety and for every purpose, from the lightest spindle oil to the heaviest gear compound and the highest grade cylinder and valve oil. There are no conditions in or around the power plant which we can not take care of with great efficiency and economy. We make this statement advisedly and confidently, for we have proven it time and time again, not alone to our own satisfaction, but to the satisfaction of any number of consumers.

The Texaco cylinder oils are carefully manufactured from high grade crudes and are strictly speaking quality products. Any conditions, from those of high pressure superheated steam to low pressure moist steam, and from the most severe and exacting work to uses where economy of feed and therefore an expensive oil is out of the question, are within the scope of our list of cylinder oils. Cylinder and valve lubrication is a very important matter; unsuitable oils are ultimately a great waste, and The Texas Company gives full and due consideration to this important branch of the lubricating business.

As for the Texaco engine and machine oils, our only regret is that the consumer does not know them as well as we do. Unfortunately it is impossible to convey to him the confidence and pride with which we regard these products. We have met so many lubricating problems and solved them with such wonderful success

that we have come to regard our oils manufactured from the low gravity Southwestern crudes with awe and respect. These are the oils, for example, which are being used in the battleships, destroyers, submarines and aeroplanes of the United States Navy, which are being installed in some of the largest plants in the United States, and which are everywhere, when properly used, giving absolute satisfaction. These oils also are being used in turbines and continuous systems where the oil has been in continuous use for over a year, and is still as good a lubricant as when first installed.

Oils from this crude cover a wide range of viscosity or body. The lightest oil is being used with the greatest success as a spindle oil in the cotton mills. The heaviest oil is heavier in body than any other straight mineral oil on the market. In between these two extremes are Texaco oils of any desired body, ranging in price from the least expensive red oils to the most expensive extra pale filtered oils.

This wide range of viscosity is important in that it does away entirely with the process of mixing oils, an expensive and wasteful practice. To use a high-priced cylinder oil to increase the body of a machine oil is not only more expensive, but the resulting lubricant is never as good as a straight mineral oil. In a typical case a mixture of steam cylinder oil and engine oil was being used, the engineer stating that it was necessary to use the cylinder oil because of the high temperature of the bearings. When the engineer of The Texas Company suggested using a regular engine oil of the proper viscosity, the engineer threw up both hands, insisting that the bearings would burn out. A test was finally made, with the following results, which are average readings taken after the bearing reached its maximum temperature:

Date	Oil	Bearing Temperature	Room Temperature	Frictional Temperature
Aug. 24	Old Mixture	170°	74°	96°
Aug. 26	Texaco Aleph Oil	138°	78°	60°
				36°

Reduction in frictional temperature 36° F., or 37.5%. After the test the mixture was again used and the temperature again went up to such a point that an order was sent in for immediate delivery of Texaco Aleph Oil.

For bearings too inaccessible for oiling, or where the pressure is very great, The Texas Company has an exceptional line of greases. The lubricating qualities of a grease are derived entirely from the oil used in its manufacture, and therefore the grease can never be any better than the oil used. Too many greases are made from cheap slop oils or even from a large percentage of water. For pump plungers and for gears The Texas Company has two special preparations called Crater Compound and Thuban Compound. They are not affected by water or by heat, will take care of the most severe conditions and will wear indefinitely.

Beginning with this edition, each issue of *Lubrication* will contain a table useful to engineers. On pages 10-11 will be found the first of this series—a table on the "Properties of Saturated Steam."

LONG TURBINE RUNS WITH TEXACO OILS

IN THE lubrication of turbines with properly arranged circulating systems, the length of time during which the circulating oil will properly lubricate is a very important feature in the economy of the unit.

This time feature is, of course, associated with the ability of the oil to separate continually from the water, to retain its viscosity and in other ways to change as little as possible from its initial condition during the time of its use.

The following records of long continuous service of Texaco oils in turbines are interesting from the evident economy, not only in amount of oil, but in the character of the lubrication and the condition of the unit at the end of the period.

In one of the large copper plants in Arizona, a test was started on November 1st, 1913, with two turbines of the same size and style, one unit being filled with Texaco oil and one unit with a competitive oil.

The units were each Curtis type, 2,000 K.W., 1,500 R.P.M., vacuum 24" receiver pressure 15, air 100 to 120. Turbine No. 1 A was filled with Texaco and No. 3 A with the competitive oil.

Unit No. 1 A has had the oil in the system continuously from November 1, 1913, to the date of this writing, September 17, 1914, and the last analysis of the oil taken out June 1, 1914, showed the following comparison with the original specifications:

	Original Specifications	Used Oil Seven Months Service
Gravity	19.7	19.6
Flash	315	320
Fire	380	375
Viscosity in seconds at 100° F.	200	206
Pour	0	0

Up to June 1, 1914, the temperature of the bearings ran 2° F. lower than those on the unit using competitive oil.

No. 3 A turbine filled with competitive oil had to be opened on May 12, 1914, after a little more than six months' service.

Upon removing the entire field, the bearings were found to be scored and rough, and covered with a heavy brown coating. A sample was taken of this oil giving the following test and comment:

Gravity	30
Flash	355
Fire	460
Viscosity in seconds at 100° F.	158
Pour	35

"The sample consisted of about ¼ oil and ¾ water and dirt. The oil was in a very complete emulsion and would not settle at all, even after heating, and it was necessary to boil the water out before the oil could be tested."

In other words, after a little more than six months' service the competitive oil had completely broken down and had not been properly lubricating for some time previously. Whereas the Texaco oil under similar conditions has lasted to date (September 17), or nearly one year, and is still in good condition.

At another mining plant in Arizona the following service was secured.

The unit was 750 K.W. Allis-Chalmers turbine, daily service being twenty-four hours, average load between 800 and 850 K.W., average R.P.M., 3,500, steam pressure 148 lbs. with 75 lbs. superheat.

This machine ran from March 24, 1913, to May 24, 1914 (*fourteen months*), without any general overhauling, though it was stopped on one or two occasions because of necessary

pipe connections in changing plant. During this period about ten gallons per month of new oil were added to the machine, usually withdrawing five gallons of old. At the end of the run the machine was in good condition.

April 13, 1914, or more than one year after the oil was put in a sample was tested and compared with the original specifications as follows:

	Original Specifications	Oil in Use 12½ Months
Gravity.....	19.7	19.1
Flash.....	315	335
Fire	380	385
Viscosity in seconds at 100° F.	200	240
Pour	0	0
Precipitation ..	....	1.8%
Fatty Oil.....	....	0.0
Acidity.....	....	0.0

TEST OF TEXACO LUBRICANTS ON NORDBERG BLOWING ENGINE

AT THE plant of one of the largest copper companies in Arizona, two Nordberg blowing engines of the same dimensions, running under the same conditions, were tested for three weeks beginning May 5th at 8 A.M. and finishing May 27th at 8 A.M.

One of these two was furnished with the competitive oils usually employed for the purpose, while the other one was tested with Texaco 650 T Cylinder oil on the H.P. steam cylinder, Texaco Draco cylinder oil on the L.P. steam cylinder, and Texaco Winner oil on the air compressor end.

Both engines were examined before the test began the initial condition of the units being as follows:

No. 14 Engine (tested with Texaco oils).

Two of the valves on H.P. air very dry and scored, No. 1 being the worst, this valve grinding; the other two valves in better condition showing lubrication at ends but dry condition in center of valve. Valves No. 1 and No. 2 on the L.P. air cylinder also showed dry and scored; condition of other two, fair.

Valves on L.P. steam cylinder dry and slightly scored.

Valves on H.P. steam cylinder have been dry—not in good condition.

No. 15 (oiled with competitive brands) showed an initial condition as follows:

Valves on H.P. steam and air grinding.

Valves on H.P. air grinding badly.

Lubricating conditions not good.

Following the starting of the test the condition of engine No. 14 improved from time to time with the use of Texaco oils as given in the engineer's detailed report.

May 9th—Valves working more smoothly on low speed, general lubricating conditions better.

" 14th—HP and LP air cylinders lubricated thoroughly at reduced feed.
Valves were rough and groaned at start but are working smooth and free.

" 17th—Lubrication good.
All roughness out of air valves.

" 25th—Lubricating conditions good.
No grinding, everything working well.

No. 15 engine, lubricated with competitive oils showed practically the same lubricating conditions at the close of the test as at the beginning.

From May 5th until May 21st, and again on May 26th, the H.P. air and steam valves on No. 15 are reported as grinding and the general conditions of the engine as described in the initial examination.

Test With Texaco Lubricating Oils

TEST WITH TEXACO 650-T CYLINDER OIL (HIGH PRESSURE), DRACO CYLINDER OIL (LOW PRESSURE) AND WINNER OIL R (AIR COMPRESSOR) ON NO. 14 NORDBERG BLOWING ENGINE, SIZE $\left.\begin{matrix}20 \times 42 \\ 44 \times 44\end{matrix}\right\} \times 42$. STEAM PRESSURE 160 LBS. 100° SUPERHEAT, 71 RPM (CONDENSING).

Date	FEED Drops per Minute H. P. Cylinder	FEED Drops per Minute L.P. Cylinder	Average Steam Pressure	Average Steam Temperature	Total (per 24 hours) Revolutions
May 6	10	4	154	472	78530
" 7			153	474	5630
" 8	7	4	154	472	42570
" 9	7	4	155	472	60550
" 10	7	4	155	472	64870
" 11			157	479	2900
" 12			157	480	12360
" 13			158	475	1160
" 14			155	472	390
" 15	8		155	472	12650
" 16	8		155	486	6660
" 17	8		165	490	59600
" 18			160	458	33900
" 19	8		160	458	69180
" 20			160	466	8260
" 21	8		168	488	20670
" 22	7		170	480	57890
" 23			163	474	62200
" 24			163	466	74110
" 25			167	460	60920
" 26			167	460	62900
				Total Rev.	797900
	Av. Rev.	per 24 hrs.,	37995.		

797,900 Total Revolutions.
Average revolutions per 24 hours, 37,995.

The summary of the report of test, which was signed by the engineer of the copper company and by our engineer, shows a remarkable saving made by the use of Texaco Oils. The quantity of both oils and saving for the test period, being as follows:

High Pressure Steam Cylinder

Competitive oil....9.7 gals.
Texaco 650 T Cylinder.....5 "

Saving.....4.7 gals. or 48.45%

Low Pressure Steam Cylinder

Competitive oil....8.6 gals.
Texaco Draco.....7 "

Saving.....1.6 gals. or 18.60%

Air Cylinders

Competitive oils...27.9 gals.
Texaco Winner....17.7 "

Saving.....10.2gals.or36.56%

Test With Competitive Oils

RECORD OF OBSERVATIONS MADE ON NORDBERG BLOWING ENGINE NO. 15 USING COMPETITIVE OILS; DUPLICATE OF ENGINE NO. 14; STEAM PRESSURE, 160 LBS; 100° SUPERHEAT; 71 RPM CONDENSING.

Date	FEED Drops per Minute H.P. Cylinder	FEED Drops per Minute L.P. Cylinder	Average Steam Pressure	Average Steam Temperature	Total Revolutions per 24 Hours
May 6			154	472	1310
" 7	12 to 14	4	153	474	60000
" 8			154	472	880
" 9			155	472	300
" 10			155	472	
" 11	12	4	157	479	43430
" 12	12		157	480	38260
" 13	12		158	475	53220
" 14	12		155	472	63260
" 15	12		155	472	62720
" 16	12		155	486	34370
" 17	12		165	490	24280
" 18			160	458	39050
" 19			160	458	
" 20			160	466	56490
" 21			168	488	51700
" 22	12		170	480	12080
" 23			163	474	51680
" 24			163	466	54870
" 25			167	460	74070
" 26			167	460	80450

Total Revolutions, 802,420.

Average Pressure, 159½; average temperature, 472⅔; average revolutions per 24 hours, 38,210.

FOR years the men connected with the Sales and Technical end of our Lubricating Division have been collecting data and making tests in scientific lubrication of machines of all kinds.

We now have on hand an enormous amount of carefully checked and tested information. This, combined with the excellent quality of the goods from which TEXACO LUBRICANTS are made and our modern methods of refining enables us to recommend and supply you with the particular lubricant needed for your particular purpose. No matter what kind of engine or machine you employ, we can confidently promise to provide efficient lubrication with **great** economy. Come to us with your problems. Our practical experience should be of incalculable value.

Drop *Lubrication* a line.

PROPERTIES OF SATURATED STEAM

THE temperature of steam in contact with water depends upon the pressure under which it is generated. At ordinary atmospheric pressure (14.7 lbs. per sq. in.) the temperature is 212° F., but as the pressure increases the temperature of both the steam and the water also increases.*

Saturated Steam is steam of the temperature due to its pressure, while Superheated Steam is steam heated to a temperature above that due to its pressure. Saturated steam cannot be cooled except by lowering its pressure. Steam in contact with water cannot be heated above the temperature due to its pressure.

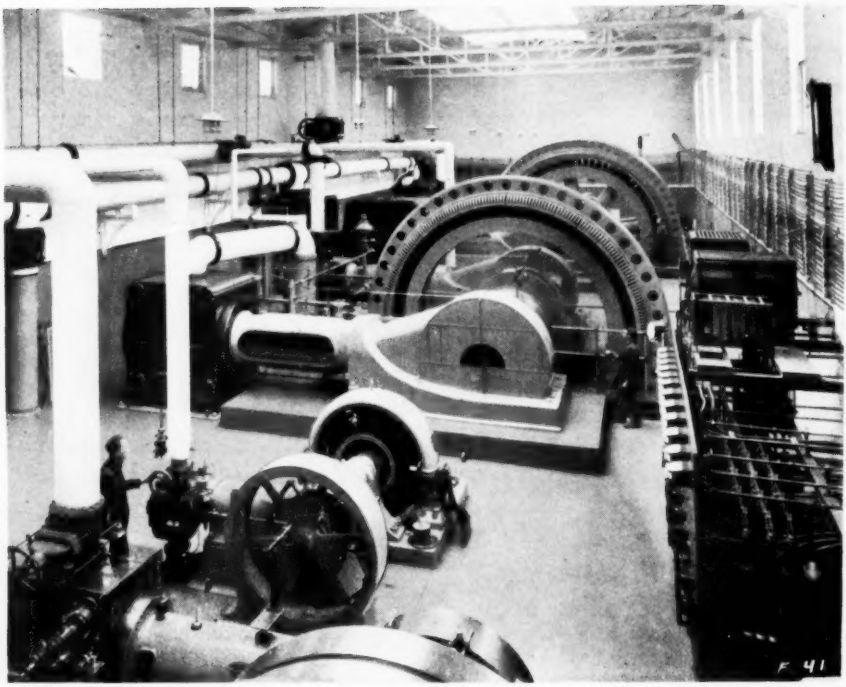
The Latent Heat or Heat of vaporization is obtained by subtracting from the total heat at any given temperature the heat of the liquid. Since the "total heat" is greater as the pressure increases, it will take more heat and consequently more fuel, to make a pound of steam as the pressure increases.

* Kent, *Mechanical Engineer's Pocket-Book*, New York, 1913, p. 836.

TABLE OF PROPERTIES OF SATURATED STEAM

Pressure in Pounds per Square Inch	Temperature Fahrenheit	Total Heat in Heat Units above 32° F.		Heat of Vaporization or Latent Heat (L) in Heat Units L=H—h	Density or Weight in Pounds of 1 Cu. Ft.	Volume in Cubic Feet of One Pound	Factor of Equivalent Evaporation at 212° F.
		In the Steam (H)	In the Water (h)				
1	101.99	1113.1	70.0	1043.0	0.00299	334.5	.9661
2	126.27	1120.5	94.4	1026.1	0.00576	173.6	.9738
3	141.62	1125.1	109.8	1015.3	0.00844	118.5	.9786
4	153.09	1128.6	121.4	1007.2	0.01107	90.33	.9822
5	162.34	1131.5	130.7	1000.8	0.01366	73.21	.9852
6	170.14	1133.8	138.6	995.2	0.01622	61.65	.9876
7	176.90	1135.9	145.4	990.5	0.01874	53.39	.9897
8	182.92	1137.7	151.5	986.2	0.02125	47.06	.9916
9	188.33	1139.4	156.9	982.5	0.02374	42.12	.9934
10	193.25	1140.9	161.9	979.0	0.02621	38.15	.9949
15	213.03	1146.9	181.8	965.1	0.03826	26.14	1.0003
20	227.95	1151.5	196.9	954.6	0.05023	19.91	1.0051
25	240.04	1155.1	209.1	946.0	0.06199	16.13	1.0099
30	250.27	1158.3	219.4	938.9	0.07360	13.59	1.0129
35	259.19	1161.0	228.4	932.6	0.08508	11.75	1.0157
40	267.13	1163.4	236.4	927.0	0.09644	10.37	1.0182
45	274.20	1165.6	243.6	922.0	0.1077	9.285	1.0205
50	280.85	1167.6	250.2	917.4	0.1188	8.418	1.0225
				913.1	0.1299	7.698	1.0245

45	274.20	1165.6	243.6	922.0	0.1077	9.285	1.0205
50	280.85	1167.6	250.2	917.4	0.1188	8.418	1.0225
55	286.89	1169.4	256.3	913.1	0.1299	7.698	1.0245
60	292.51	1171.2	261.9	909.3	0.1409	7.097	1.0263
65	297.77	1172.7	267.2	905.5	0.1519	6.583	1.0280
70	302.71	1174.3	272.2	902.1	0.1628	6.143	1.0295
75	307.38	1175.7	276.9	898.8	0.1736	5.760	1.0309
80	311.80	1177.0	281.4	895.6	0.1843	5.426	1.0323
85	216.02	1178.3	285.8	892.5	0.1951	5.126	1.0337
90	320.04	1179.6	290.0	889.6	0.2058	4.859	1.0350
95	323.89	1180.7	294.0	886.7	0.2165	4.619	1.0362
100	327.58	1181.9	297.9	884.0	0.2271	4.403	1.0374
105	331.13	1182.9	301.6	881.3	0.2378	4.205	1.0385
110	334.56	1184.0	305.2	878.8	0.2484	4.026	1.0396
115	337.86	1185.0	308.7	876.3	0.2589	3.862	1.0406
120	341.05	1186.0	312.0	874.0	0.2695	3.711	1.0416
125	344.13	1186.9	315.2	871.7	0.2800	3.571	1.0426
130	347.12	1187.8	318.4	869.4	0.2904	3.444	1.0435
140	352.85	1189.5	324.4	865.1	0.3113	3.212	1.0453
150	358.26	1191.2	330.0	861.2	0.3321	3.011	1.0470
160	363.40	1192.8	335.4	857.4	0.3530	2.833	1.0486
170	368.29	1194.3	340.5	853.8	0.3737	2.676	1.0502
180	372.97	1195.7	345.4	850.3	0.3945	2.535	1.0517
190	377.44	1197.1	350.1	847.0	0.4153	2.408	1.0531
200	381.73	1198.4	354.6	843.8	0.4359	2.294	1.0545
225	391.79	1201.4	365.1	836.3	0.4876	2.051	1.0576
250	400.99	1204.2	374.7	829.5	0.5393	1.854	1.0605
275	409.50	1206.8	383.6	823.2	0.5913	1.691	1.0632
300	417.42	1209.3	391.9	817.4	0.644	1.553	1.0657
325	424.82	1211.5	399.6	811.9	0.696	1.437	1.0680
350	431.90	1213.7	406.9	806.8	0.748	1.337	1.0703
375	438.40	1215.7	414.2	801.5	0.800	1.250	1.0724
400	445.15	1217.7	421.4	796.3	0.853	1.172	1.0745
500	466.57	1224.2	444.3	779.9	1.065	.939	1.0812



ONE OF THE LARGE AUTOMOBILE PLANTS IN WISCONSIN

THE floor space of this plant covers approximately forty acres, and there is no room wasted. It contains every conceivable piece of machinery that an automobile factory could possibly demand, delicate and rugged; costly and inexpensive; large and small, all lubricated with Texaco Oils.

Texaco Oils were installed in this plant after comparative tests were run in all departments by the engineers of The Texas Company, working together with the engineer of the plant. As the metallurgical engineer of the plant recently expressed it, "The reason for the installation of Texaco Oils simmered down to one word: 'Diagnosis'. It was the first real intelligent study of our conditions that was ever made. The history of the case was given, conditions were analyzed, and the prescription was written and is being refilled every day since the signing of our contract with The Texas Company. It is all a case of the right oil in the right place."

TEXACO SERVICE

There are a great many factors which enter into the causes of improper lubrication which would not occur to the average layman or appear to him to have any connection whatever with his lubricating conditions. For example, the lubrication of a steam cylinder may be affected by the condition of the boiler water, the nature and quantity of boiler com-

pound used, the distance of the boilers from the engine, and numerous other features. In the general lubrication of equipment throughout the plant there are also many conditions affecting lubrication, which may escape the notice of an engineer, but which are quickly discernible to the lubricating expert. When the engineers of The Texas Company go into a plant with the idea of improving the lubricating conditions, they make a study of each individual unit, and in making any changes or recommendations in the system of applying lubricants or in the grades of oil in use at the time, they do so with the view of installing such oils as will lubricate in the most efficient manner possible, and, at the same time, with the greatest degree of economy.

In several instances our engineers have gone into plants where there have never been any lubricating difficulties and have nevertheless shown remarkable savings. In one of the large steel mills in Ohio, which was taken over by one of our engineers, a saving of $12,000 was shown in one year. In another instance, in a large steel foundry where the works manager apparently had his oil consumption reduced to the minimum, we were able to show a saving of 23.7% in cost of lubrication.

TEXACO PRODUCTS IN LUMBER MILL POWER PLANT

IN ADDITION to the formal tests which are made with Texaco Lubricating Oils, we are continually securing information from various power plants showing the effect of the operation of these oils in the plant with such observations and information as may have been gathered by the engineer in charge.

One of these records is given below and speaks for itself in the conclusions of the Chief Engineer, from whom the report was received.

The lumber company owning this power plant is one of the largest in the southeast, and the mill itself is the second largest sawmill in the south.

The units mentioned are Turbine generator 700 K.W., 25 K.W. exciter, motor generator set 250 K.W., Corliss engine 28 x 48, 100 R.P.M., direct connected to 500 K.W. generator.

The report of the Chief Engineer of the lumber company is as follows:

"With our turbine room at a temperature of 98° F., cooling water at temperature of 78° F., the turbine bearings showed temperature of 130°F. The oil, after passing through the bearing, but before going through the cooler, had a temperature of 125° F. This turbine is 700 K.W., 3 phase, 60 cycle, 3,600 R.P.M., and had been on the run 72 hours when test was made, the load varying from ⅔ to 25% over-load. This turbine has been running three months, and we have not added a drop of oil since starting up. To the best of my belief, it will take about four gallons of oil to bring the oil tank to the same level as when we started. The oil retains its original color, and on comparing it with unused oil you cannot detect which is which.

"On an exciter 25 K.W., 3,600 R.P.M., with ring oilers, not water cooled, that had been running continually four weeks, the bearing temperature was 136° F. The engine room temperature at 98° F. On a motor generator set 250 K.W., capacity 600 R.P.M., using motor oil the bearings were at a temperature of 122° F., engine room at 98° F.

"This was all the time I had to spare, but as soon as I can will take temperature of all bearings and will be glad to let you have them. On the Corliss engine 20 x 48, 100 R.P.M., 110 lbs. steam, direct connected to 500 K.W. generator, we use two quarts of Summit Valve on a ten-hour run."

EFFECTS OF CONTINUOUS USE UPON AN OIL

BEFORE the development of the present day circulating systems, all of the oil fed through the oil cups was delivered to the bearings where it performed its duty, and was then allowed to run off and go to waste. With the systems now in use, however, it is possible (when using a suitable oil and a proper system), to use the oil over and over again. Further, by making a sufficient addition of fresh oil replacing the loss through evaporation and leakage, the system can be kept running indefinitely. Whether or not a plant uses enough oil to warrant the installation of such a lubricating system is a matter for each owner to decide. If the amount of oil saved and deterioration of machinery prevented is sufficient to make a paying investment of the amount spent for such an installation, business economy would demand such a lubricating system.

The systems for applying oil to all types of mechanical equipment are many and varied. The three principal ones are Force Feed Mechanical Lubricators for steam cylinder lubrication, Individual Circulating Filtering Systems for small units, and Central Circulating Filtering Systems for large power plants where there are two, three, or more units in operation.

In regard to the durability of an oil and its use over and over again in the same system, engineers frequently speak of oil "wearing out"; some even go so far as to maintain that after oil has been in use for a certain length of time it should be discarded and replaced with new oil. In order to determine exactly the deterioration which oil suffers when constantly in use, Cornell University recently carried on a series of tests in its laboratories on different samples of oil. These tests tend to prove that if an oil is high grade, carefully manufactured, it can be used indefinitely, without losing any of its lubricating properties. The plant from which the oil was taken for the test is equipped with a central circulating and filtering system, supplying flooded lubrication to four Wetherill engines having forty-eight points of lubrication, two Clayton air compressors having six points of lubrication, two Laidlaw compressors having sixteen points of lubrication, one Wetherill crank and flywheel pump having thirty-two points of lubrication, making a grand total of one hundred and thirty-four points of lubrication supplied by this system. The plant operates twenty-four hours a day, three hundred and sixty-five days in the year, and the average temperature of the engine room is 100° F. On account of the great variety of machines lubricated, the high load factor and the exceptional temperature conditions, the work imposed upon this lubricating system is probably as severe as can be found in any plant. The average amount of oil handled by the lubricating system was one hundred and fifty gallons per hour, which is equivalent to 1,800 barrels per month. It is interesting to note that, although this large amount of oil is supplied continuously to the bearings, it is necessary for the plant to add to the system only three barrels of oil per month; and only a portion of this amount can be charged to natural shrinkage of the oil, as oil drawn and used from cans for hand oiling of small pumps, valves, gear and other bearings is naturally lost.

To determine the changes undergone by the oil a sample of new oil, was secured, as received in barrels from the manufacturers, also a sample of oil drawn from the clean oil compart-

ment of the filter of the lubricating system. These samples were sealed in the engine room and shipped to the testing department at Cornell University, where, without any further purification or filtration, tests were made under the supervision of Prof. Carpenter and Prof. Sawdon.

A series of friction tests was made on a Thurston Railroad Lubricant Tester having a hardened steel journal and bronze bearings with a total area of twenty square inches. In all tests the testing machine was run at a constant speed of about 360 R. P. M., and the load applied in increments of 1,500 lbs. total pressure, or 75 lbs. per square inch. The test at each load was continued until the friction and temperature of the bearings had become constant. The oil was fed through a sight feed oiler and the feed maintained as nearly constant as possible throughout all the tests. Readings were made at ten-minute intervals.

The coefficient of friction shown in the accompanying curve chart represents the lowest value found for each load. As soon as a given load is applied the coefficient is high at first and gradually falls off until it becomes practically constant, representing the value that would be obtained in ordinary practice where engines operate continuously for more than an hour. The temperature shown in chart number 2 is the highest temperature reached for each load; that is, as each new load is applied the bearing gradually heats up until the temperature becomes practically constant.

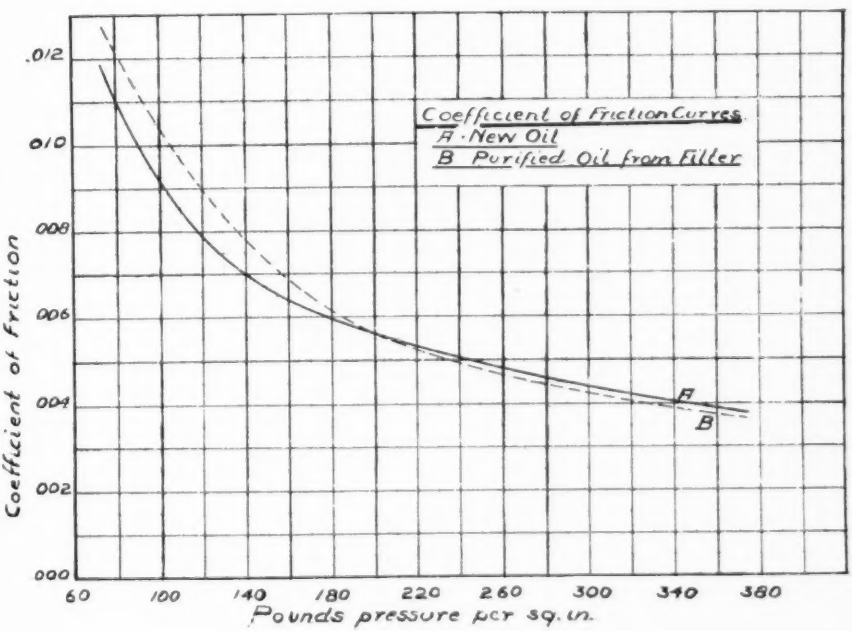


Fig. 1

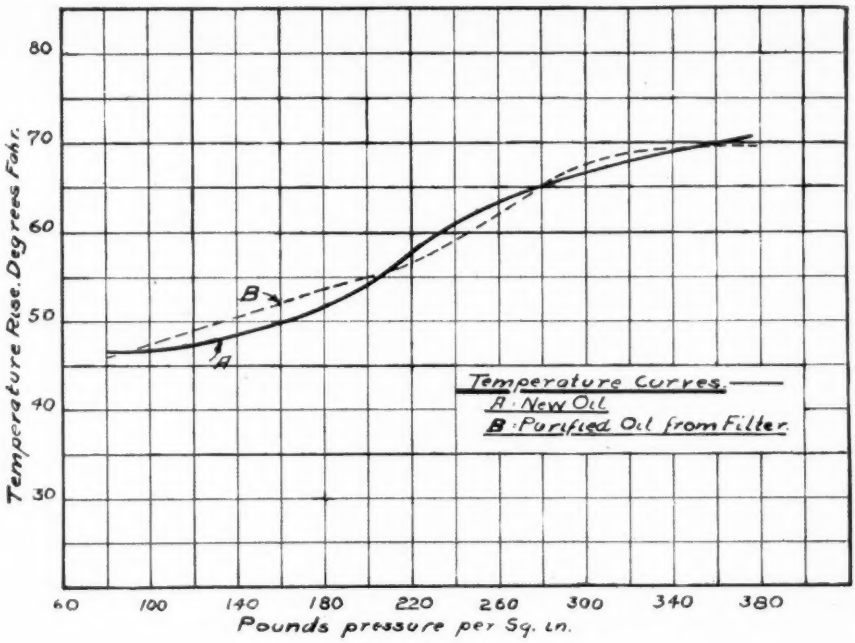

Temperature Rise. Degrees Fahr.
80
70
60
50
40
30
B
A
Temperature Curves.
A: New Oil
B: Purified Oil from Filter.
60
100
140
180
220
260
300
340
380
Pounds pressure per Sq. in.

FIG. 2

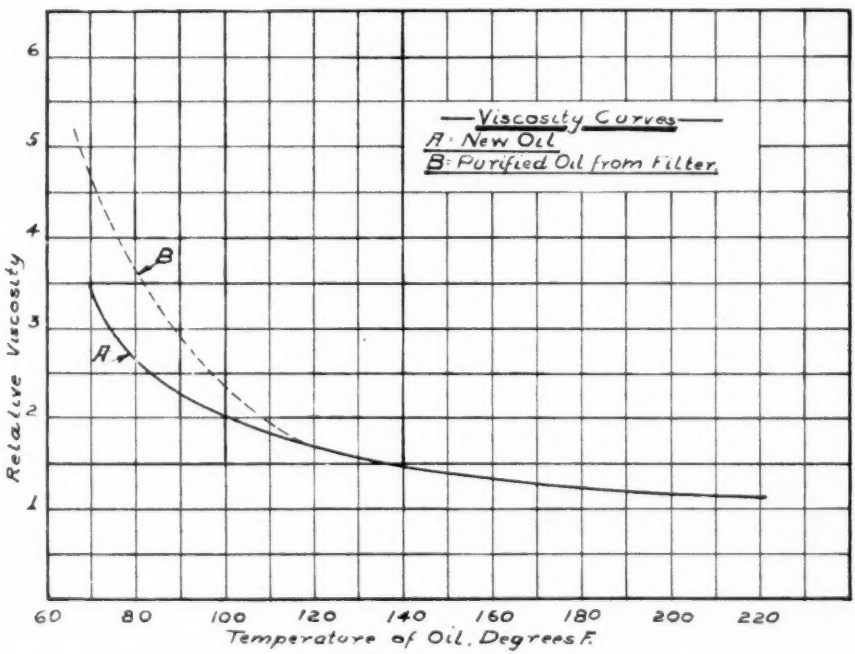

Relative Viscosity
6
5
4
3
2
1
Viscosity Curves
A: New Oil
B: Purified Oil from Filter.
B
A
60
80
100
120
140
160
180
200
220
Temperature of Oil, Degrees F.

FIG. 3.

By closely examining chart 3 it can be seen that the lubricating value of the filtered oil has been in no way impaired, showing very clearly what can be accomplished in the way of economical and efficient lubrication where the proper oil and system is used.

As mentioned above, about three barrels of new oil are added to this system per month, and as the system as a whole had been in operation for over a year and a half when the test was made, the question naturally arose as to what physical changes the oil had undergone during this period. The oil gained in specific gravity through constant use. This is what would be expected inasmuch as the oil, in passing through the bearings has had some of its more volatile constituents driven off. Furthermore, a small quantity of cylinder oil used for lubricating the piston rods and stuffing boxes naturally finds its way into the oiling system. The viscosity curves also confirm this hypothesis, as the tests show that the used oil has a higher viscosity than the new, indicating that as oil is used over and over again in an oiling system, it gains in body if the filter thoroughly removes entrained water.

The result of the friction tests, as shown in Fig. 1, are also consistent with these physical changes. It will be noted that the new oil has a slightly lower coefficient of friction on low bearing pressures, while the filtered oil shows a lower coefficient on higher bearing pressures. The old oil, having more body, is better able to maintain a lubricating film when subjected to higher pressure. The difference between these two curves is so slight, however, that one can practically say that they indicate that properly filtered oil is as good a lubricant as new oil.

The curves showing the coefficient of friction are interesting to the operating engineer, as it is usually by the temperature of the bearings that he determines the quality of lubrication. As will be noted, these curves are practically superimposed and in no case is the variation more than a few degrees, so that here again it is indicated that filtered oil is as good as new oil.*

A LETTER FROM DISBROW

St. Louis, Mo., Aug. 10, 1914.

THE TEXAS CO.,

McCormick Bldg., Chicago, Ill.

GENTLEMEN:

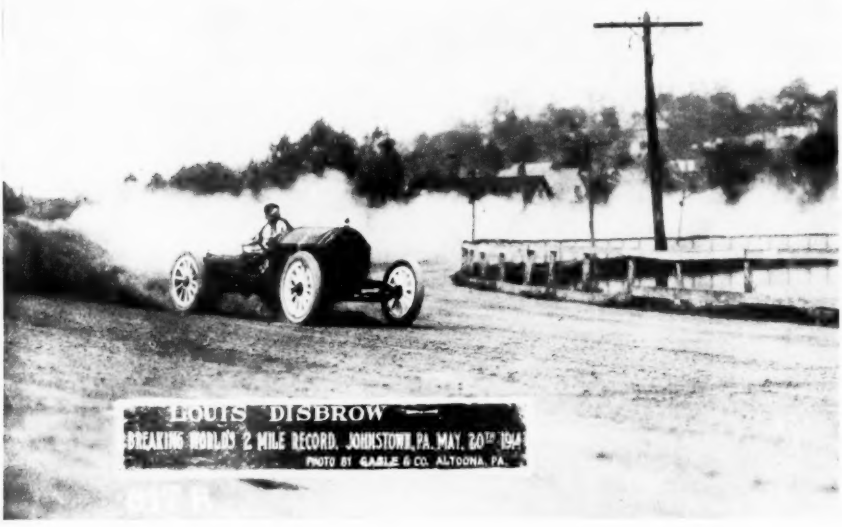
After having thoroughly tested your Texaco Oil for the last three years under the most strenuous conditions which would have been possible to subject any lubricants to, I wish to state a few facts which I think might be interesting to your Experimental Department:

As stated above, I have used Texaco Oil exclusively in the Simplex Zip for the last three years, with the exception of about two months of this year, when circumstances compelled me to use another lubricant, for which I was very glad as I was thereby enabled to make some very interesting comparisons. I found when using this other oil that in the first place I used about 20% more gasoline, and I attributed this to the fact that it was necessary for me to use almost fifty percent more oil, or in other words, my exhaust was always smoky, and that, as you know, takes a heavier mixture. I have always used a Motometer, and am convinced of its accuracy. I find in using Texaco, the temperature of the motor is reduced 20° F., and on a cool day it is necessary to cover a portion of the radiator in order to bring the temperature of the motor to 180° F., which I think the most efficient point.

* See the article in *The Automobile* of May 7, 1914, p. 964, entitled "Oil Economy in Jeffrey Plant."

The two previous years of racing which I did with the Simplex, I had never found it necessary to take up a bearing or to remove carbon or grind valves during the entire season. When I was using the other two lubricants in two months of racing, it was necessary for me to remove carbon twice, grind my valves twice, and take up the bearings once. I might add that I was using a lubricant that is used by many racing drivers. I do not care to mention the name, and sincerely trust that you do not know what oil I was using. As you probably have followed my racing for the last three years and know that it is a very strenuous one; I might state that I have done in the last three years over 10,000 miles of racing, which you know is about three times as much as any other car is called upon to do, the class of racing which I was doing is particularly hard on the motor and lubricants due to the fact that I almost continually drive in blinding clouds of dust. This comes in through the carburetor and practically doubles the work an oil is asked to do. I have also done over 2,000 miles of beach racing, which I consider the very hardest of all on car and lubrication, due to the fact that the fine white sand will get up into the working parts no matter how well protected. During the races held here on the 8th and 9th I lowered the record for one and two miles, which now gives to the car and myself every world's record from one to fifty miles. I am proud to say that Texaco products assisted me most materially, and I have used nothing else.

I wish to congratulate you most heartily on the service that your oil has given us.

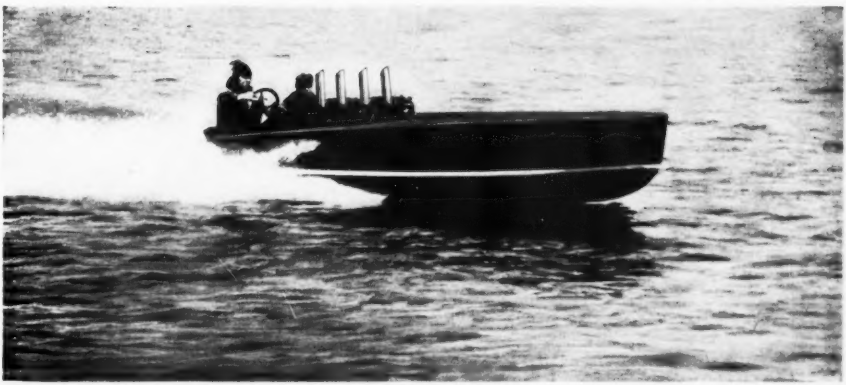


Thanking you for your many courtesies and with the kindest regards, I beg to remain,

Respectfully yours,

(Signed) LOUIS DISBROW.

[Since the writing of this letter Louis Disbrow also set a new world's record for two miles on a half-mile track. This was accomplished at Oklahoma City, Okla., on October 2d, 1914, the time being two minutes, thirteen and three-fifths seconds. As usual he used Texaco Motor Oil and Texaco Gasoline.]



AT THE recent races held at Lake George, N. Y., "Baby Speed Demon," owned by Mrs. Paula H. Blackton, and driven by Robert Edgren, Sporting Editor of the New York *World*, won the Gold Challenge Cup, establishing a new world's record of 50.59 miles per hour for one mile, miles being nautical miles, using Texaco Motor Oil, E. H. and Texaco Gasoline. Several boats using competitive oils burned out their bearings and were compelled to retire from the races.

In the races of the Motor Boat Club of Buffalo held during the early part of September seven entrants took part in the three days' racing. "Baby Speed Demon, II," driven by Mr. Edgren, took two firsts and a second. "Baby Speed Demon," using Texaco Motor Oil, E. H. and Texaco Gasoline, has been the most reliable and most successful boat of the year, winning six firsts and always finishing in nine free-for-all scratch races. The following letter indicates the attitude of Mr. Edgren toward Texaco oil and gas:

New York, Aug. 21, '14.

Mr. E. C. Cheney
The Texas Company,
McCormick Bldg., Chicago, Ill.

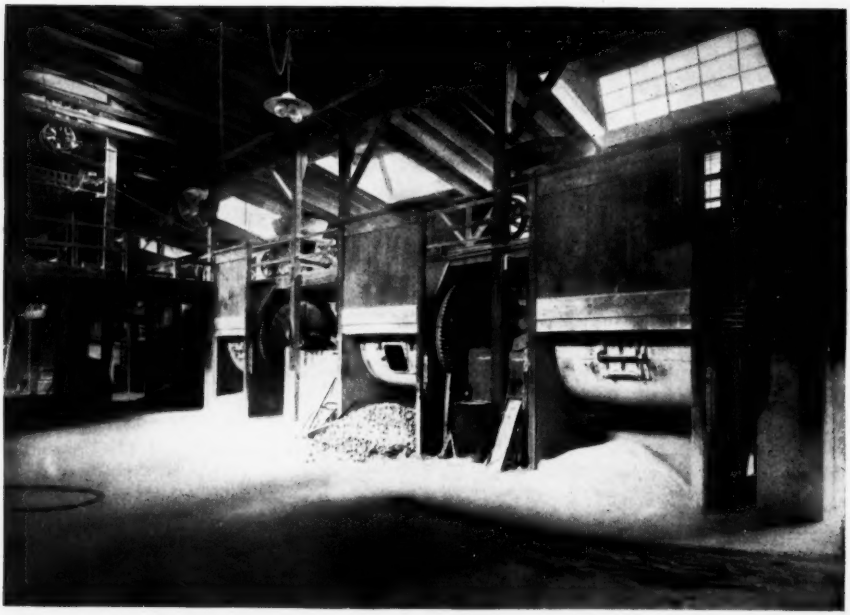
MY DEAR CHENEY:

I expect to drive Baby Speed Demon II again at Buffalo and hope to see you there. Probably I won't be able to go up until the day before the race. I suppose they'll all be using your oil and gas by this time, which will make the racing closer and more exciting. Expect to have even more fun than at Lake George.

I'm much obliged to you for putting me next to that Texaco Motor Oil, E. H. You know how the old Reo was rattling over the bumps and up the grades. Since you first filled the tank with your oil she has been going along as if there was a muffler on every bearing—not a clank or a rattle out of her. Texaco is good enough for me in the future. My motor has much better compression and more power than with the other oil I was using. It surely goes up hill better. And a tankful of your oil lasts twice as long as any other I've tried. . . . .

Yours truly,
(Signed) ROBERT EDGREN.

The winners of the South Jersey Racing Association also used Texaco Motor Oil, E. H. The champion "Jay Dee Ess," made a clean sweep through the racing season, not only having finished every race in which she has been entered, but in every case crossing the line a winner. The performance of this hydroplane has been truly remarkable, her engines having been working perfectly and having at no time been in the shop for repairs.



TEXACO CRATER COMPOUND AT WORK

THE above photograph shows three of the drums and gears in the plant of one of the largest producers and manufacturers in the country of kaolin or feldspar, from which is made pottery, tile and porcelain goods. These drums or cylinders when empty weigh about seven tons each, and carry when loaded about sixteen tons. They are used for breaking up the feldspar, which is accomplished with the aid of two tons of French flint stones in each drum to break and powder the feldspar. The gear wheels around these drums are about seven feet in diameter and about five inches wide.

Texaco lubricants have been used in the plant for several years for general work, but it was not until recently that Texaco Crater Compound was given a trial on these gears. The fact was that the Company had become discouraged in their attempt to lubricate these large open gears satisfactorily, but they became enthusiastic after they had given Crater Compound a trial. One application of Crater Compound is now giving good lubrication for a period of about five days, twenty-four hours per day, whereas it had formerly been impossible to secure a lubricant which would stick to the gears under this heavy load.

Crater Compound is especially adapted for this kind of work. In fact this particular job presented less difficulty than much of the work successfully accomplished by this compound. This lubricant will not only stand up under any load, but is practically indestructible, and readily resists the action of heat or of fresh or salt water. For the lubrication of chains and cables it has no equal.